TITLE OF INVENTION

Occupant Sensor f r a V hicl Restraint System

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

BACKGROUND OF THE INVENTION

1. Field of Invention

[0003] This invention pertains to an apparatus to sense seated occupants for a vehicle occupant restraint system. More particularly, this invention pertains to the use of sensors to measure seat deflection, and the use of electrical signals to determine if the person's weight and seating position are such that an airbag should be deployed.

2. Description of the Related Art

[0004] Air bags are important safety devices in modern motor vehicles. There have been, however, injuries associated with the actuation of air bags located in front of and to the side of the passenger seats of vehicles. The occupant of a passenger seat may be injured by the air bag if the occupant is a baby or child in a child seat, a small child, or a child or adult seated too close to the air bag on the front portion of the seat. Attempts to prevent actuation of air bags under unfavorable circumstances are known in the art.

[0005] United States Patent Number 6,015,163, titled "System for Measuring Parameters Related to Automobile Seat," issued to Langford et al. on January 18, 2000, discloses a system that determines whether an air bag should be deployed in the case of an automobile crash. The system uses flexible potentiometers placed in an X-Y grid to determine the weight and position of a person. Position and weight

are determined by monitoring a group of flexible potentiometers, each positioned between two turns of a coil spring **74** in or under a seat cushion or seat surface. Langford also discloses a flexible potentiometer attached to the main surface of a leaf spring **100**. As a load or force is applied to the spring, the flexible potentiometers produce a resistance change.

[0006] United States Patent Number 5,474,327, titled "Vehicle Occupant Restraint with Seat Pressure Sensor," issued to Schousek on December 12, 1995, discloses a system that disables actuation of an air bag when an occupant weight that is less than a minimum weight and/or a weight center is forward of a reference line. The seat occupant sensing system includes a voltage divider, having a fixed resistor **26** in series with a pressure sensor or variable resistor **28**. Each sensor is mounted between polymer film sheets and includes a pair of conductive electrodes separated by a carbon layer such that the resistance between the electrodes changes as pressure changes. The type of variable resistor is not discussed.

[0007] United States Patent Number 6,161,439, titled "Seat Belt Tension Prediction," issued to Stanley on December 19, 2000, discloses a seat belt tension prediction system which includes an accelerometer and a seat weight sensor. The seat weight sensor includes a plurality of force sensitive resistive elements **42** which provide a variable electrical resistance responsive to the amount of force acting on the elements **42**. The type of force sensitive resistive element is not disclosed.

[0008] United States Patent Number 6,092,838, titled " System and Method for Determining the Weight of a Person in a Seat in a Vehicle," issued to Walker on July 25, 2000, discloses the use of load sensor beams to detect a person seated in a vehicle seat. Strain gauges **104a-d**, which are variable resistance strain gauges, are used to quantify the weight of the person sitting on the seat.

[0009] United States Patent Number 6,513,830, titled "Method and Appartus for Disabling an Airbag System in a Vehicle," issued to Breed et al. on February 4, 2003 discloses a method and apparatus for determining the position of a seat using a potentiometer **601**. The potentiometer **601** is positioned along the seat

track **602**, and a sliding brush assembly **603** is used to determine the fore and aft location of the seat **610**.

[0010] United States Patent Number 5,232,243, titled "Occupant Sensing Apparatus," issued to Blackburn et al. on August 3, 1993, discloses an occupant sensing apparatus having an occupant sensor **60** located in the bottom cushion **42** of an automobile seat **34**. The occupant sensor **60** is a multi-layer piezoelectric film sensor **110**

BRIEF SUMMARY OF THE INVENTION

[0011] According to one embodiment of the present invention, an apparatus for determining the presence, weight, and seated location of an occupant in a vehicle seat is provided. The apparatus uses sensors to measure seat deflection to determine whether an airbag should be deployed in the case of an automobile crash. In one embodiment, the apparatus includes sensors that transfer linear movement to a processor which controls air bag deployment. In another embodiment, the apparatus includes sensors with rotary potentiometers to transfer movement to a processor which controls air bag deployment.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0012] The above-mentioned features of the invention will become more clearly understood from the following detailed description of the invention read together with the drawings in which:

Figure 1 is a perspective view of an occupant sensing apparatus fixed to a vehicle seat and connected to a processor that controls an air bag system;

Figure 2a is a perspective view of one embodiment of an occupant sensing apparatus;

Figure 2b is a plan view of the occupant sensing apparatus of Figure 2a showing nine zones;

Figure 3 is a cross-sectional view of one embodiment of a sensor;

Figure 4 is a cross-sectional view of another embodiment of a sensor;

Figure 5 is a perspective view of still another embodiment of a sensor;

Figure 6 is a schematic diagram of one embodiment of an occupant sensing apparatus connected to a processor;

Figure 7 is a schematic diagram of another embodiment of an occupant sensing apparatus connected to a processor;

Figure 8 is a schematic diagram of still another embodiment of an occupant sensing apparatus connected to a processor;

Figure 9 is a schematic diagram of yet another embodiment of an occupant sensing apparatus connected to a processor;

Figure 10 is a side view of another embodiment of a rotary sensor; and

Figure 11 is a side view of still another embodiment of a rotary sensor.

DETAILED DESCRIPTION OF THE INVENTION

[0013] An occupant sensing apparatus **10** for sensing the presence, weight, and position of a person or object in a vehicle seat is disclosed. The apparatus uses sensors **202** to determine whether an airbag should be deployed in the case of an automobile crash.

[0014] The term "person" refers to a human driver or passenger in a vehicle. The term "object" refers to non-human items located on a vehicle seat. In one embodiment, a baby seat is an object. The term "occupant" refers to a person and/or an object that occupies or is located on a vehicle seat. The term vehicle or automobile is intended to include passenger cars, vans, trucks, airplanes, and other vehicles that employ air bags or use occupant restraint systems.

[0015] In one embodiment, presence, weight, and position of an occupant are determined. In other embodiments, only one or some of these indicators are determined. The term 'presence' simply indicates whether an occupant is sitting in

a seat. In one embodiment, if presence is not detected, the air bag system will disable. The term 'position' simply indicates seating location or where an occupant is putting weight on the seat. The term 'weight' is loosely used in the invention to refer to the heaviness or lightness of an occupant. The apparatus does not indicate an actual measurement of the occupant's weight in pounds or kilograms. Rather, in one embodiment, weight is understood as the force that the occupant exerts normal to the seat surface. In another embodiment, weight is the pressing force that the occupant exerts. Deflection of the seat caused by the occupant in a seat is a measurement of weight. For example, a light person around 50 pounds will create less downward deflection than a heavier person that weighs around 200 lbs. It is not necessary that the weight be accurately measured over a broad range. The accuracy of measuring weight is typically important only near a threshold point.

[0016] Figure 1 illustrates one embodiment of the apparatus **10** in which a sensor assembly **102** affixed to or placed under a vehicle seat **104**. The sensor assembly **102** is connected to a processor **106**, and the processor **106** controls deployment of an air bag system **108**. When a person sits on the vehicle seat **104**, the foam or deflection material **110**, **110'** on the sitting portion of the seat deflects varying amounts at different locations, which permits the sensing apparatus **10** to determine the presence, position, and/or weight of the person. This information is transmitted to the processor **106** which determines whether to deploy the air bag system **108** in the case of an automobile crash. In one embodiment, the sitting portion of the seat **104** is that portion illustrated in Figure 1 as the deflection material **110**. In another embodiment, the sitting portion of the seat **104** includes a seat back, or back of the seat against which the occupant leans. In still another embodiment, the sitting portion of the seat **104** includes a head rest.

[0017] In one embodiment, the vehicle seat **104** is the front passenger seat; however, in other embodiments, the vehicle seat **104** is any seat in the vehicle that accommodates an occupant restraint system. Further, in one embodiment, the vehicle seat **104** includes a bottom cushion **110** where a person sits and a back cushion **110'** against which the person leans against. However, in other embodiments, the vehicle seat **104** includes the other parts of the seat where deflection can be measured, such as the head rest.

[0018] Those skilled in the art will recognize that the deflection material **110, 110'** is any material or spring suspension that deflects when a force is applied to the material. This includes the standard cushion or foam that already exists in most vehicles. The invention does not require that the deflection be directly proportional to the force applied but requires only that a deflection occurs when a force is applied to the deflection material **110, 110'**. The sensor assembly **102** is placed under and/or behind the deflection material **110, 110'**. Those skilled in the art will recognize that the occupant sensing apparatus is affixed under the seat either to the bottom of the seat, to the floor board of the vehicle, or to the structural supports underneath or in the seat without departing from the spirit and scope of the present invention.

[0019] As used herein, the processor **106** should be broadly construed to mean any computer or component thereof that executes software. The processor **106** includes a memory medium that stores software, a processing unit that executes the software, and input/output (I/O) units for communicating with external devices. Those skilled in the art will recognize that the memory medium associated with the processor **106** can be either internal or external to the processing unit of the processor without departing from the scope and spirit of the present invention.

[0020] In one embodiment the processor **106** is a general purpose computer, in another embodiment, it is a specialized device for implementing the functions of the invention. Those skilled in the art will recognize that the processor **106** includes an input component, an output component, a storage component, and a processing component. The input component receives input from external devices, such as the sensors **202**. The output component sends output to external devices, such as the air bag system **108**. The storage component stores data and program code. In one embodiment, the storage component includes random access memory. In another embodiment, the storage component includes non-volatile memory, such as floppy disks, hard disks, and writeable optical disks. The processing component executes the instructions included in the software and routines.

[0021] Those skilled in the art will recognize that the air bag system **108** is any occupant restraint system and can be used without departing from the spirit and scope of the present invention. In one embodiment, variable air bags are used. Variable air bags are air bags that deploy with a varying amount of force or velocity depending on the presence of different sized and shaped objects in a vehicle seat. In another embodiment, the air bag system **108** is a standard non-variable air bag or one which is pre-existing in the vehicle.

[0022] In one embodiment, the input from the processor **106** to the air bag system **108** functions to disable and prevent actuation of the air bag system **108** if the input is below a threshold amount, or alternatively, depending on the design of the apparatus **10**, above a threshold amount. In another embodiment, in order to prevent the air bag system **108** from injuring a person above or below the threshold weight in the vehicle seat **104**, the air bag system **108** is disabled when the detected weight of the person in the vehicle seat **104** is below a lower weight limit or above an upper weight limit.

[0023] In one embodiment which involves a baby or child in a child seat, the detected weight is the weight of the baby or child seated in the child seat, plus the weight of the child seat. Therefore, when there is a child seat on the vehicle seat, the weight of the person seated in the vehicle seat **104** is defined to be the weight of the baby or child seated in the child seat, plus the weight of the child seat. In one embodiment, to prevent the air bag system **108** from injuring babies and small children seated in child seats, the occupant sensing apparatus **10** detects the presence of the child seat and disables the air bag system **108**. In another embodiment, the air bag **108** is disabled when the detected weight of the child in the vehicle seat **104** or the child plus the weight of the child seat are below a lower weight limit.

[0024] One embodiment of the invention disables air bag actuation when the weight of the person on the vehicle seat **104** is above an upper weight limit. This is accomplished by the sensor assembly **102** measuring an upper threshold weight limit. The processor controls the air bag system **108** when the weight is below the lower weight limit or above the upper weight limit. Deployment of the air bag

system **108** is disabled above the upper weight limit to prevent the air bag system **108** from injuring very large adults that, due to their size, would be located very close to the air bag system **108**. The upper weight limit is a very large amount of weight, for example about three hundred (300) pounds. One embodiment reduces the force or the velocity of the air bag when the detected weight is above or below threshold values. Another embodiment disables or reduces the force or the velocity of the air bag when the detected seating position of the person is in a location that could cause injury to the person.

[0025] Figure 2a illustrates one embodiment of the sensor assembly **102**. Nine sensors **202a-i** are mounted as an assembly on a frame **204**. The frame **204** is affixed to a vehicle seat using two fasteners **206a&b** on opposite ends of the frame **204** so that the tops of the sensors **202a-i** are biased upward and press lightly against the inside surface of the foam or deflection material **110**, **110'**. In other embodiments, the tops of the sensors **202a-i** are attached, either mechanically or chemically, to the inside surface of the foam or deflection material **110**, **110'**. Such attachment can by clips, fasteners, adhesive, or other attachment means securing the movable portion of the sensors **202** to the deflection material **110**, **110'**.

[0026] Figure 2b illustrates one embodiment in which the sensors **202a-i** are positioned in a grid of three columns of three rows. The seat **110** has nine zones, or areas, in which the occupant is detected. The seat **110** is divided front to back into thirds **222**, **224**, **226** and again from side to side into thirds **212**, **214**, **216**, thereby forming nine zones. Each sensor **202** is positioned in a corresponding zone, e.g., sensor **202g** is located in a corner zone **212-222**. The presence, position, and weight of an occupant is determined by the amount of deflection of each sensor **202** in each zone **212-222** to **216-226**. The grid of zones **212-222** to **216-226** allows the determination of the occupant's front-to-back and side-to-side position on the seat **104**.

[0027] In other embodiments, the number of sensors **202** mounted to the frame **204** or used in the sensor assembly **102** includes more or less than nine sensors **202**. Those skilled in the art will recognize that the number and location

of the sensors **202** mounted on the frame can vary without departing from the spirit and scope of the present invention. In one embodiment, only one sensor **202** is used in the middle of the vehicle seat **104** for detection of both presence and weight of an occupant. If detection of a child safety seat is required, one embodiment includes sensors **202** positioned to detect the presence of a child safety seat and a person. With increasing numbers of sensors **202**, the detection of the person or object becomes more accurate.

[0028] Those skilled in the art will recognize that the frame **204** is any plastic molded, metal, or material able to mount the assembly of sensors **202**. In one embodiment, the floor board under the vehicle seat **104** is used as the frame for the sensors **202**. In another embodiment, the sensors **202** are held stationary with respect to the seat **104** and the movable portion of each sensor **202** is attached to the frame **204** or vehicle.

[0029] The sensors **202** are mounted using any means to stabilize the sensors to the frame. Those skilled in the art will recognize that this includes means such as soldering, use of adhesives, or frames designed or altered to stabilize the sensors without departing from the spirit and scope of the present invention.

[0030] In one embodiment, the frame **204** is attached to the vehicle seat **104** or affixed under the vehicle seat **104** to stabilize the sensor assembly **102**. In another embodiment, the sensor assembly **102** is positioned in any part of the vehicle seat. This includes the head rest, the back support, the vehicle seat cushion and any other location that requires occupant detection. By placing the sensor assembly **102** in various or numerous places in the vehicle seat **104**, detection of a person or object's position becomes more easily detected. Further, in one embodiment where a sensor assembly **102** is placed in the back support of the vehicle seat **104**, the recline of the vehicle seat can be determined. When a person is reclined in a vehicle seat **104**, the person may be injured if an air bag is actuated in the case of an automobile crash. The recline of a vehicle seat **104**, therefore, is another factor that commonly is necessary when deciding if an air bag system **108** should be actuated.

[0031] In one embodiment, the assembly sensor **102** does not require fasteners **206** because the frame or sensors **202** are stabilized by simply positioning them in or under the vehicle seat **104**. In embodiments that require fastening to the vehicle seat **104**, floor board, or other structural support in the vehicle, those skilled in the art will recognize that fasteners **206** can be any attachment device that attaches the frame **204** to the vehicle seat **104**, floor board, or other structural support in the vehicle such that the top of the sensors **202** press lightly against the bottom of the foam or deflection material **110** on the vehicle seat **104**. Further, in various embodiments, the position of the fasteners **206** and the layout or design of the frame **204** varies according to the particular vehicle seat **104** or location within the vehicle seat **104** that requires the sensor assembly **102**.

[0032] The embodiment illustrated in Figures 1, 2a, and 2b uses custom designed sensors **202** with wiper arm potentiometers. Potentiometers are transducers that change electrical resistance from a linear or rotational motion. Potentiometers are used in a wide variety of devices and the technology is mature. There are many existing types of potentiometers including carbon film, wire wound, and cermet (ceramic-metal). Potentiometers are useful because their life, precision, and accuracy are predictable and they are relatively unaffected by changes in environmental factors such as temperature and humidity. Further, potentiometers use little energy and are relatively unaffected by outside influences such as electromagnetic radiation.

[0033] Figure 3 illustrates one embodiment of a sensor **202**. A moveable member, such as an actuator **302**, moves in a vertical direction due to the displacement of the seat material **100** caused by a person sitting in a vehicle seat **104**. As the actuator **302** displaces, a connecting member, such as an actuator shaft **306**, connected to the actuator **302**, operates a potentiometer **322**. A wiper arm **314**, which moves with the actuator **302**, slides against a resistive member, such as a resistive strip **316**, causing changes in resistance between terminals **318b** and **318c** or **318a** and **318c** as the actuator **302** moves up or down.

[0034] More specifically, the illustrated embodiment of a sensor includes an actuator **302** which contacts foam or deflection material **110** in a vehicle seat **104**. The actuator **302** contains an actuator shaft **306** that slides inside a potentiometer **322**. The potentiometer **322** is a cylindrical unit **304** that contains a dust seal **320** at the opening where the actuator shaft **306** enters the unit **304**. Inside the cylindrical unit **304**, the actuator shaft **306** is attached to a shuttle **308**. Underneath the shuttle **308** is a compression spring **310** that sits on the bottom of the cylindrical unit **304**. Between the shuttle **308** and the spring **310** is a metal wiper **312** that extends up one side of the shuttle **308** to form a wiper arm **314**. The wiper arm **314** is a brush. Inside and along the side of the cylindrical unit **304** is a resistive strip **316**. The resistive strip **316** is a material with a resistance, such as carbon or cermet (ceramic-metal). In one embodiment, the resistive strip is linear, that is, the resistance change is proportional to the deflection caused by the application of weight to the seat **104**. In another embodiment, the resistance of the resistive strip is non-linear, that is, the resistance changes with a non-linear relationship to the deflection. The resistive strip **316** is positioned such that the wiper arm **314** contacts the resistive strip **316** while the actuator **302** moves up and down. Strip connections **318a-c** extend from opposite ends of the resistive strip **316** and the bottom of the compression spring **310** outside of the cylindrical unit **304** to the processor **106**.

[0035] Various portions of the under area of the vehicle seat deflect downward in response to weight on the vehicle seat **104**. In various embodiments, the deflection is not directly proportional or maintains a linear relationship to the weight introduced. The point of contact is any point that moves downward due to the weight of the person sitting in the vehicle seat **104**. When a person sits in the vehicle seat **104**, the force of the person's weight moves the actuator **302**. The actuator **302** slides inside the cylindrical unit **304** causing the shuttle **308** to compress the spring **310**. When the shuttle **308** and the spring **310** move downward, the wiper arm **314** moves along the resistive strip **316** causing a change in resistance between the wiper arm **314** and strip connections **318 a&b**. The strip connections **318** are electrical connections or wires that connect the sensor **202** to the processor **106**. In one embodiment, the change in resistance is a direct function of the deflection of the wiper arm **314** for linear resistive strips **316**.

Those skilled in the art will recognize that the actuator **302** and the actuator shaft **306** can be one member or two members without departing from the spirit and scope of the present invention.

[0036] The potentiometer **322** does not always require a cylindrical unit **304**. Further, those skilled in the art will recognize that the cylindrical unit **304** includes any shape or housing that allows contact between the wiper arm **314** and resistive strip **316** as the actuator **302** changes positioning and can be used without departing from the spirit and scope of the present invention. In the illustrated embodiment, the sensor **202** is spring biased upward and presses lightly against the foam or deflection material **110** in the vehicle seat **104**. In the illustrated embodiment, a compression spring **310** is used under the shuttle **308** to allow the actuator **302** to return to a neutral position when force is removed. In other embodiments, the spring is located such that it forces the actuator **302** (and the connecting member **306** and the shuttle **308** because of their connection to the actuator **302**) to return to a neutral position. In still another embodiment, the sensor **202** does not have a spring **310**, but rather the actuator **302** is attached to the deflection material **110** such that the actuator **302** moves in concert with the deflection material **110**. That is, the actuator **302** moves in both directions by virtue of its connection to the deflection material **110**.

[0037] Figure 4 illustrates another embodiment of a sensor **202'**. The actuator **302** is attached to a flexible shaft **404** that slides inside a tube **402**. The flexible shaft **404** slides within the tube **402** and extends into the potentiometer **322**. In one embodiment, the top of the tube **402** is secured relative to the occupant sensing apparatus frame **204** such as with a clamp **406**. Those skilled in the art will recognize that the tube **402** is secured using any stabilizing mechanism that secures the tube while the flexible shaft **404** slides along the tube **402**. When a force is applied to the top of the actuator **302**, the flexible shaft **404** slides inside the tube **402** and the cylindrical unit **304** of the potentiometer **322** causing the shuttle **308** to compress the spring **310**. When the shuttle **308** and the spring **310** move, the wiper arm **314** moves along the resistive strip **316** causing a change in resistance between the wiper arm **314** and strip connections **318 a&b**.

[0038] The tube **402** is hollow and functions as a passage for the flexible shaft **404**. Those in the art will recognize that the tube is any material able to hold the flexible shaft without departing from the spirit and the scope of the invention. In one embodiment, the tube **402** encompasses the entire flexible shaft **404**. In another embodiment, the tube **402** encompasses only a portion of the flexible shaft **404**. In another embodiment, the tube **402** is a flexible or articulating tube, which allows additional flexibility in locating the potentiometer **322**.

[0039] In the illustrated embodiment, the orientation of the actuator shaft **404** is varied to suit instances where there is a limited amount of room under the vehicle seat **104**. Compared to the embodiment illustrated in Figure 3, the space savings from the embodiment illustrated in Figure 4 involves the approximate sum of the compressed height of the spring **310**, the thickness of the shuttle **308**, and the thickness of the end of the cylindrical unit **304**.

[0040] For example, if the under area of a vehicle seat **104** is approximately four inches, the vertical positioning of the sensor as shown in Figure 3 without the flexible shaft **404** may be too tall to easily fit under the seat. For example, if the cylindrical unit **304** is 3 inches tall and the actuator shaft **306** sits 2 inches above the potentiometer **322** when no force is applied, there would not be enough room underneath the vehicle seat **104** for the sensor assembly **102**. However, if the cylindrical unit has a width of approximately one inch, the embodiment illustrated in Figure 4 allows plenty of space for the sensor assembly **102** underneath the vehicle seat **104** with the potentiometer **322** mounted sideways. The sensor **202** with the flexible shaft **404** would require less than three inches under the seat as opposed to five inches required by the sensor **202** with the vertical actuator shaft **306**.

[0041] Figure 5 illustrates still another embodiment of a sensor **202"**. The actuator **302** has an actuator shaft **502** with teeth **504** along the side. The teeth **504** accommodate gears **506** that are attached to a rotary potentiometer **508**. At the bottom of the actuator shaft **502** is a compression spring **510**. When a force is applied to the top of the actuator **302**, the actuator shaft **502** and teeth **504** move

downward causing the gears **506** on the potentiometer **508** to rotate and thereby, create a change in resistance in the potentiometer **508**.

[0042] In the illustrated embodiment, the teeth **504** on the actuator shaft **502** encompass the entire shaft. In another embodiment, the teeth do not entirely encompass the actuator shaft **502** but only cover a portion of the actuator shaft **502**. In still another embodiment, the teeth **504** are carved into or are within the actuator shaft **502**.

[0043] In another embodiment, the actuator shaft **502** rotates the shaft of the rotary potentiometer **508** by frictionally causing a wheel (not illustrated) attached to the potentiometer shaft to rotate as the actuator shaft **502** moves linearly. In still another embodiment, the actuator **302** is attached to the deflection material **110** and moves as the deflection material **110** moves. In this embodiment, there is no spring **510** because the actuator **302** and actuator shaft **502** move in concert with the deflection material **110**.

[0044] Figure 6 illustrates one embodiment of a schematic diagram of the sensor assembly **102** connected to the processor **106**. The illustrated embodiment shows three sensors **202a**, **202b**, **202c.** A voltage source **602** is connected to the sensors **202** and to the processor **106**. Each sensor **202** is also directly connected to the processor **106**.

[0045] The outputs from the various sensors **202** to the processor **106** establish the seating position of the person. In the illustrated embodiment, three sensors **202a**, **202b**, and **202c** are positioned in three different zones, for example X, Y, and Z, respectively, underneath the vehicle seat. Each of these sensors **202a**, **202b**, and **202c** are directly connected to the processor **106**. The zones are regions or divided portions of the vehicle seat **104** where occupants generally sit or lean. For example, sensor **202a** is located in zone X which corresponds to the back sitting portion of the vehicle seat **104** and sensor **202b** is located in zone Y which corresponds to the middle portion of the vehicle seat **104**. If an occupant sits in zone X, all sensors **202a** , **202b**, and **202c** will measure some or no deflection and the processor **106** will determine the sitting position based on the amount of deflection measured by each sensor **202a** , **202b**, and **202c**. In this

case, the processor **106** will recognize that an occupant is positioned in the back sitting portion of the vehicle seat **104**. If a deflection also occurs in sensor **202b**, the processor will recognize that an occupant is positioned in both zone X, the back sitting portion, and zone Y, the middle portion, of the vehicle seat. Each sensor **202a**, **202b**, and **202c** also have an electrical voltage output V1, V2, and V3, respectively. When a person sits on the vehicle seat, each sensor **202a**, **202b**, and **202c** will have an amount of deflection corresponding to the amount of force provided by the person in each respective zone X, Y, or Z. For example, sensor **202a** deflects two inches while sensor **202b** only deflects one inch and sensor **202c** does not deflect at all. This means that the person is putting more weight in zone X than in zone Y and little to no weight in zone Z. Based on the amount of deflection in each zone, each sensor will in turn produce a voltage output V1, V2, and V3 to the processor **106**. The processor **106** then determines the seating position of the person based on the amount of deflection for each sensor **202a**, **202b**, and **202c**. In one embodiment, weight is determined by the processor using a lookup table based on the amount of deflection measured in each zone. In another embodiment, weight is determined by an algorithm executed by the processor.

[0046] To protect persons sitting to close to the air bag system **108**, one embodiment enables the processor **106** to disable the air bag system **108** if the deflection in the zone closest to the air bag system **108** or on the front of the vehicle seat **104** exceeds a certain amount.

[0047] The outputs from the various sensors **202** to the processor **106** also establish the weight or presence of the person. In one embodiment, once the seating position of the person is identified, the deflection from each of the sensors **202a**, **202b**, and **202c** is further used to determine the weight of the person. Since the seat **104** is divided into zones, the processor **106** identifies the zones that the person is sitting in using the position values. The processor then determines weight based for those particular zones. Weight, like the seating position, is determined by using the amount of deflection from each sensor **202a**, **202b**, and **202c**. The weight is calculated in the processor **106** based on the voltages V1, V2, and V3. These voltages are from the deflection change of each of

the sensors **202a**, **202b**, and **202c**, respectively. In one embodiment, the processor **106** adds the voltages V1, V2, V3 based on the deflection from each sensor **202a**, **202b**, and **202c** or zone. If the total voltage V1 + V2 + V3 is above or below a threshold amount, the processor **106** disables the air bag system **108**. In another embodiment, if V1 + V2 +V3 is within a certain amount, the processor **106** will disable the air bag system **108**. In yet another embodiment, the weight is determined not by adding the voltages, but by the processor **106** executing an algorithm, or function, or look up table in which the deflection in the zones or of the sensors **202** determines the weight. In one embodiment, there are as many zones as there are sensors **202** and each sensor **202** has its own zone. In another embodiment, there are multiple sensors **202** in each zone.

[0048] In one embodiment, each of the functions are performed by one or more software routines run by the processor **106**. In another embodiment, one or more of the functions identified are performed by hardware and the remainder of the functions are performed by one or more software routines run by the processor **106**. In still another embodiment, the functions are implemented with hardware, with the processor **106** providing routing and control of the entire integrated system.

[0049] The processor **106** executes software, or routines, for performing various functions. These routines can be discrete units of code or interrelated among themselves. Those skilled in the art will recognize that the various functions can be implemented as individual routines, or code snippets, or in various groupings without departing from the spirit and scope of the present invention. As used herein, software and routines are synonymous. However, in general, a routine refers to code that performs a specified function, whereas software is a more general term that may include more than one routine or perform more than one function.

[0050] Figure 7 illustrates another embodiment of a schematic diagram of the sensor assembly **102** connected to the processor **106**. A voltage source **602** is connected to the sensors **202a**, **202b**, and **202c** and to the processor **106**. Each of the sensors **202a**, **202b**, and **202c** are connected directly to the processor **106**.

In the illustrated embodiment, sensors **202b&c** provide voltage outputs that are dependent upon the position of sensor **202a**.

[0051] Figure 8 illustrates yet another embodiment of a schematic diagram of the sensor assembly **102** connected to the processor **106**. A voltage source **602** is connected to the sensors **202a**, **202b**, and **202c** and to the processor **106**. The wipers **312** of each sensor **202a**, **202b**, and **202c** are connected to each other and then connected to the processor **106**.

[0052] Figure 9 illustrates still yet another embodiment of a schematic diagram of the sensor assembly **102** connected to the processor **106**. One side of a voltage source **602** is connected to the sensors **202a**, **202b**, and **202c**. The wipers **312** of each sensor **202a**, **202b**, and **202c** are connected directly to the processor **106**.

[0053] Figures 6 through 9 are examples of four embodiments of connections of the sensor assembly **102** to the processor **106**. Those skilled in the will recognize that variations of Figures 6 through 9 can be used without departing from the scope and spirit of the present invention. Further, in Figures 6 through 9, only three sensors **202** are shown. In other embodiments, the number of sensors **202** varies. Further, those skilled in the art will recognize that the resistance of the sensors **202** may be different and may have linear or nonlinear outputs without departing from the spirit and scope of the present invention.

[0054] Figure 10 is a side view of another embodiment of a rotary potentiometer **508** operated by deflection of the deflection material **110**. An actuator arm **1002** attached to the shaft of the rotary potentiometer **508** moves in concert with the actuator **302**, which is attached to the deflection material **110**. As the deflection material **110** deflects, the actuator **302** moves, causing the rotary potentiometer **508** to change resistance. In the illustrated embodiment, the actuator **302** is attached, either mechanically or chemically, to the surface of the foam or deflection material **110**. In another embodiment, the actuator **302** is lightly biased against the deflection material **110** by a spring. Although the illustrated embodiment shows the deflection material **110** being that of the sitting portion of the seat **104**, those skilled in the art will recognize that the deflection

material **110'** of the seat back or the head rest can also be used with this embodiment of the sensor **202**.

[0055] Figure 11 is a side view of still another embodiment of a rotary potentiometer **508** operated by deflection of the deflection material **110**. An actuator cam **1102** is lightly biased against the deflection material **110** such that as the deflection material **110** moves, the cam **1102** is moved about the shaft of the rotary potentiometer **508**. Although the illustrated embodiment shows the deflection material **110** being that of the sitting portion of the seat **104**, those skilled in the art will recognize that the deflection material **110'** of the seat back or the head rest can also be used with this embodiment of the sensor **202**.

[0056] The apparatus **10** for sensing occupants in a vehicle includes various functions. The function of sensing deflection of a seat surface is implemented by the various embodiments of the sensors **202, 202', 202"** depicted in Figures 3, 4, 5, 10, and 11. The function of varying a resistance based on the deflection is implemented by the potentiometer **322, 508**. The function of controlling an air bag system **108** based on the resistance is implemented, in various embodiments, by the processor **106** executing a process for determining the presence, weight, and/or position of an occupant in a vehicle seat **104** in response to the positions of the sensors **202** in each zone **212-222** to **216-226**. In one embodiment, the weight is determined by a look up table. In another embodiment, the weight is determined by an algorithm calculating the weight based on the deflection in each zone **212-222** to **216-226**.

[0057] From the foregoing description, it will be recognized by those skilled in the art that an apparatus to sense seated occupants for a vehicle occupant restraint system has been provided. The apparatus uses sensors which transfer linear or rotational movement to determine the presence, weight, and seating position of a person in a vehicle seat.

[0058] While the present invention has been illustrated by description of several embodiments and while the illustrative embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages

and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicant's general inventive concept.